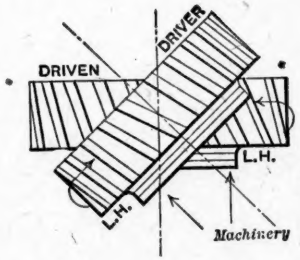
SPIRAL GEARS WITH SHAFTS AT ANY ANGLE—III

Shafts at Any Angle, Ratio Unequal, Center Distance Approximate



The sum of the spiral angles of the two gears equals the shaft angle, and the gears are of the same hand, if each angle is less than the shaft angle. The difference between the spiral angles equals the shaft angle, and the gears are of opposite hand, if either angle is greater than the shaft angle.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. C_a = center distance.
3. P_n = normal pitch (pitch of cutter).
4. R = ratio of gear to pinion = $N \div n$.
5. α = angle of spiral on gear.
6. β = angle of spiral on pinion.
7. n = number of teeth in pinion nearest $\dfrac{2\,C_a\,P_n \cos\alpha \cos\beta}{R\cos\beta + \cos\alpha}$ for any angle, and $\dfrac{2\,C_a\,P_n\cos\alpha}{R+1}$ when both angles are equal.
8. N = number of teeth in gear = $R\,n$.

To find:

1. D = pitch diameter of gear = $\dfrac{N}{P_n\cos\alpha}$. 2. d = pitch diameter of pinion = $\dfrac{n}{P_n\cos\beta}$.
3. O = outside diameter of gear = $D + \dfrac{2}{P_n}$. 4. o = outside diameter of pinion = $d + \dfrac{2}{P_n}$.
5. T = number of teeth marked on cutter for gear = $N \div \cos^3\alpha$.
6. t = number of teeth marked on cutter for pinion = $n \div \cos^3\beta$.
7. L = lead of spiral on gear = $\pi D \cot\alpha$. 8. l = lead of spiral on pinion = $\pi d \cot\beta$.
9. C = actual center distance = $\dfrac{D+d}{2}$.

Example

Given or assumed (Angle of shafts, 60 degrees):

1. See illustration. 2. C_a = 12 inches. 3. P_n = 8.
4. R = 4. 5. α = 30 degrees. 6. β = 30 degrees.
7. $n = \dfrac{2\,C_a\,P_n\cos\alpha}{R+1} = \dfrac{2\times 12\times 8\times 0.86603}{4+1}$ = 33 teeth. 8. $N = 4\times 33$ = 132 teeth.

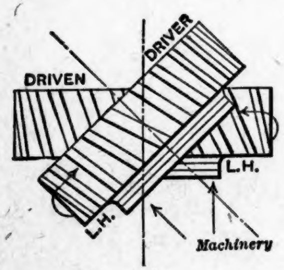
To find:

1. $D = \dfrac{N}{P_n\cos\alpha} = \dfrac{132}{8\times 0.86603}$ = 19.052 inches. 2. $d = \dfrac{n}{P_n\cos\beta} = \dfrac{33}{8\times 0.86603}$ = 4.763 inches.
3. $O = D + \dfrac{2}{P_n} = 19.052 + \dfrac{2}{8}$ = 19.302 inches. 4. $o = d + \dfrac{2}{P_n} = 4.763 + \dfrac{2}{8}$ = 5.013 inches.
5. $T = N \div \cos^3\alpha = 132 \div 0.65$ = 203 teeth. 6. $t = n \div \cos^3\beta = 33 \div 0.65$ = 51 teeth.
7. $L = \pi D\cot\alpha = \pi\times 19.052\times 1.732$ = 103.66 inches.
8. $l = \pi d\cot\beta = \pi\times 4.763\times 1.732$ = 25.92 inches.
9. $C = \dfrac{D+d}{2} = \dfrac{19.052 + 4.763}{2}$ = 11.9075 inches.

Contributed by James H. Carver

SPIRAL GEARS WITH SHAFTS AT ANY ANGLE—IV

Shafts at Any Angle, Ratio Unequal, Center Distance Exact



The sum of the spiral angles of the two gears equals the shaft angle, and the gears are of the same hand, if each angle is less than the shaft angle. The difference between the spiral angles equals the shaft angle, and the gears are of opposite hand, if either angle is greater than the shaft angle.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. C = center distance.
3. P_n = normal pitch (pitch of cutter).
4. α_a = approximate spiral angle of gear.
5. β_a = approximate spiral angle of pinion.
6. R = ratio of gear to pinion = $N \div n$.
7. n = number of teeth in pinion nearest $\dfrac{2\,C\,P_n\cos\alpha_a\cos\beta_a}{R\cos\beta_a + \cos\alpha_a}$
8. N = number of teeth in gear = $R\,n$.

To find:

1. α and β, exact spiral angles, found by trial from $R\sec\alpha + \sec\beta = \dfrac{2\,C\,P_n}{n}$.
2. D = pitch diameter of gear = $\dfrac{N}{P_n\cos\alpha}$. 3. d = pitch diameter of pinion = $\dfrac{n}{P_n\cos\beta}$.
4. O = outside diameter of gear = $D + \dfrac{2}{P_n}$ 5. o = outside diameter of pinion = $d + \dfrac{2}{P_n}$.
6. T = number of teeth marked on cutter for gear = $N \div \cos^3\alpha$.
7. t = number of teeth marked on cutter for pinion = $n \div \cos^3\beta$.
8. L = lead of spiral on gear = $\pi D\cot\alpha$. 9. l = lead of spiral on pinion = $\pi d\cot\beta$.

Example

Given or assumed (Angle of shafts, 60 degrees):

1. See illustration. 2. C = 40 inches. 3. P_n = 4.
4. α_a = 20 deg. 5. β_a = 40 deg. 6. R = 3.
7. $n = \dfrac{2\,C\,P_n\cos\alpha_a\cos\beta_a}{R\cos\beta_a + \cos\alpha_a} = \dfrac{2\times 40\times 4\times 0.9397\times 0.766}{(3\times 0.766) + 0.9397}$ = 71 teeth.
8. $N = R\,n = 3\times 71$ = 213 teeth.

To find:

1. α and β from $R\sec\alpha + \sec\beta = \dfrac{2\,C\,P_n}{n} = \dfrac{2\times 40\times 4}{71}$ = 4.507. By trial $\alpha = 22°\ 24'\ 30''$ and $\beta = 37°\ 35'\ 30''$.
2. $D = \dfrac{N}{P_n\cos\alpha} = \dfrac{213}{4\times 0.92449}$ = 57.599 inches.
3. $d = \dfrac{n}{P_n\cos\beta} = \dfrac{71}{4\times 0.79238}$ = 22.401 inches.
4. $O = D + \dfrac{2}{P_n} = 57.599 + \dfrac{2}{4}$ = 58.099 inches. 5. $o = d + \dfrac{2}{P_n} = 22.401 + \dfrac{2}{4}$ = 22.901 inches.
6. $T = N \div \cos^3\alpha = 213 \div 0.79$ = 270 teeth. 7. $t = n \div \cos^3\beta = 71 \div 0.497$ = 143 teeth.
8. $L = \pi D\cot\alpha = \pi\times 57.599\times 2.4252$ = 438.8 inches.
9. $l = \pi d\cot\beta = \pi\times 22.401\times 1.2989$ = 91.41 inches.

Contributed by James H. Carver